# SERVICE MANUAL

# CRT Data Display
# TTL Series

5-017-1017

Oct. 27, 1976

Revision B

BALL BROTHERS RESEARCH CORPORATION

ELECTRONIC DISPLAY DIVISION

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TABLE OF CONTENTS

# Section 1
# GENERAL INFORMATION

## 1.1 MONITOR DESCRIPTION

The TTL series Data Display monitor is a solid-state unit for use in industrial or commercial installations where reliable, high quality video reproduction of white alpha-numeric on a black raster.

The monitor features printed circuit board construction for reliability and uniformity. All circuits of the TTL monitor are transistorized. The synchronization circuits have been custom designed to accept video as well as vertical and horizontal drive signals to enable interfacing of this monitor with industrial or digital TTL sources. This feature simplifies the user's sync processing and mixing and allows the unit to operate without composite sync. The electronic packaging has been miniaturized for compatibility with small volume requirements.

## 1.2 ELECTRICAL SPECIFICATIONS

Input Data Specifications

| | Video | Vertical Drive Signal | Horizontal Drive Signal |
|---|---|---|---|
| Input Connector | (Necessary Accessory-Available) Printed circuit board card edge connector- Viking #2VK10S/1-2 or Amphenol #225-21031-101 | | |
| Pulse Rate or Width | Pulse Width: 45 nsec or greater | Pulse Rate: 47 to 63 pulses/ sec | Pulse Rate: 15,000 to 16,500 pulses/sec |
| Amplitude | Low = Zero $^{+0.4}_{-0.0}$ volts; High = +4 ± 1.5 volts | | |
| Signal Rise & Fall Times (10% to 90% amplitude) | Less than 20 nsec | Less than 100 nsec | Less than 50 nsec |
| Input Signal Format | See Figure 1 | | |

Data Display Specifications

| Input Impedance | Minimum Shunt Resistance | Maximum Shunt Resistance |
|---|---|---|
| (a) Video Input: | 3.3K ohms | 40pF |
| (b) Vertical Drive Input: | 3.3K ohms | 40pF |
| (c) Horizontal Drive Input: | 3.3k ohms | 40pF |

Video Amplifier

| | | |
|---|---|---|
| (a) | Bandwidth: | 15 MHz (-3 dB) |
| (b) | Rise and Fall Times (10% to 90% amplitude): | Less than 35 nsec. (linear mode) |
| (c) | Storage Time: | 15 nsec, maximum (linear mode) |

Retrace and Delay Times

| | | |
|---|---|---|
| (a) | Vertical: | 900 µsec retrace, maximum |
| (b) | Horizontal: | 9 µsec retrace, maximum |

Display Specifications

Cathode Ray Tube: (without bonded panel)

| Nominal Diagonal Measurement (inches) | Phosphor | *Resolution (TV Lines) | |
|---|---|---|---|
| | | Center | Corner |
| 15 | P4 | 1000 at 40 fL | 800 at 40 fL |
| | P39 | 1000 at 20 fL | 800 at 20 fL |
| *Resolution is measured in accordance with EIA RS-375 except Burst Modulation (or Depth of Modulation) is adjusted for 100 percent. | | | |

Geometric Distortion

Geometric Distortion as measured using an "EIA Linearity Chart" in accordance with EIA RS-375 shall be equal to or less than 1.5 percent of the active raster height.

Power Requirements

Power Specifications:

| | |
|---|---|
| Input Connector | Receptacle, Molex #03-06-2041 Supplied with Unit Mating Plug, Molex #03-06-1041-Necessary Accessory (Available) |
| Input Voltage | 105V to 130V rms (120V nominal); 50/60hz |
| Input Power | 40W (nominal) for 525/60 models. |
| Output Voltages | +55 VDC (short circuit protected)<br>+17 kVDC; 6.3V rms |

## 1.3 ENVIRONMENTAL SPECIFICATIONS

Temperature (Chassis or Custom Unit)

| | |
|---|---|
| Operating Range: | 5°C to 55°C Ambient |
| Storage Range: | -40°C to 65°C |

Humidity

5 to 80 percent (Noncondensing)

Altitude

| | |
|---|---|
| Operating Range: | Up to 10,000 feet |

## 1.4 HUMAN FACTORS SPECIFICATIONS

X-Ray Radiation

These units comply with DHEW title 21, Subchapter J.

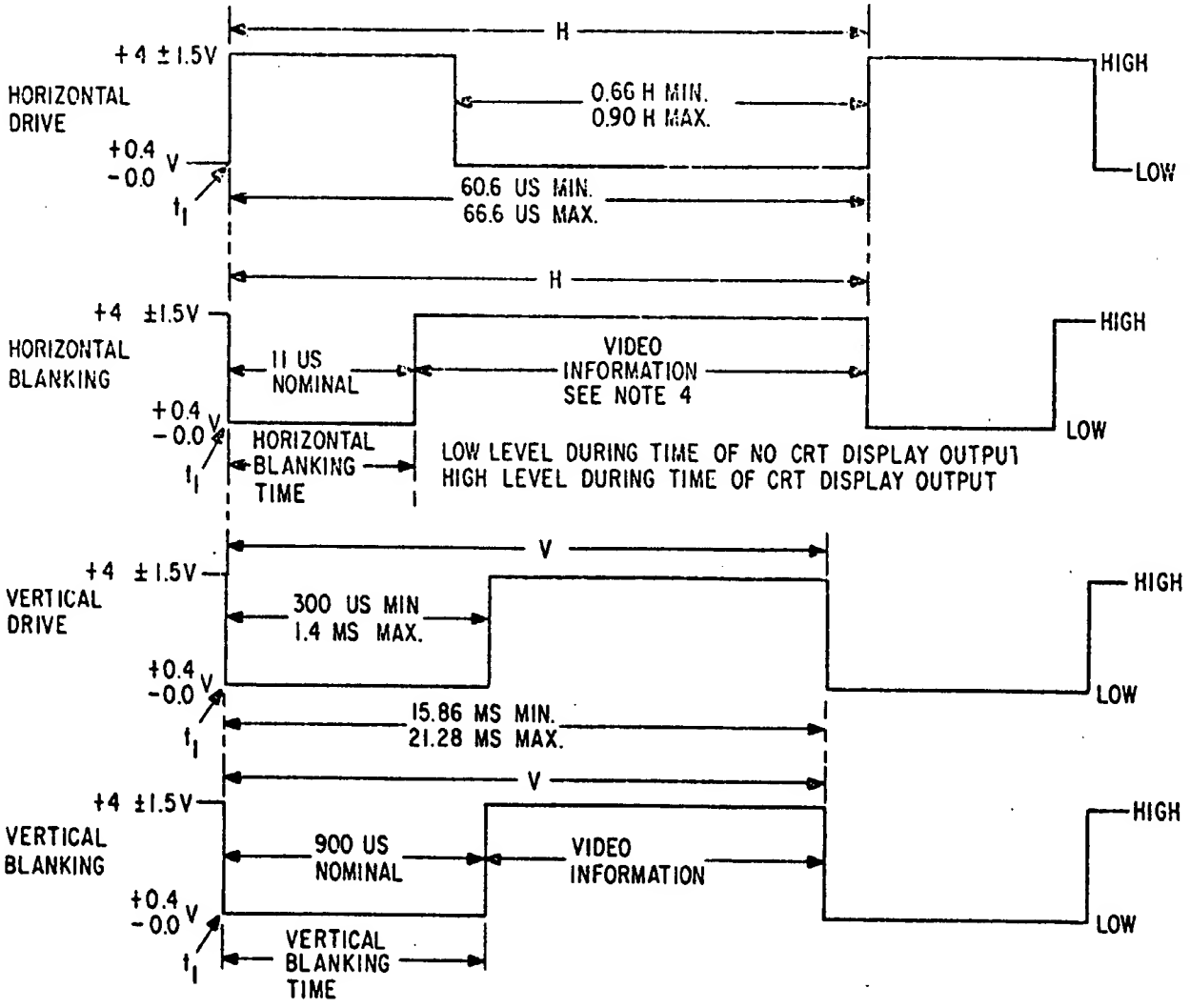
## 1.5 CONTROLS

Customer Access - Necessary Accessories (Available)

(1) Contrast, 500 ohm potentiometer carbon composition ≥1/8 Watt
(2) Brightness, 100 kilohm potentiometer ≥1/8 Watt
Optional: The Brightness Control can be mounted on the printed circuit board as an internal set up control.

Internal Set Up Controls

(1) Height
(2) Vertical Linearity
(3) Vertical Hold
(4) Focus
(5) Width
(6) Low Voltage Adjust
(7) Horizontal Centering
(8) Video Gain Adjust




NOTES

1. The leading edges of Drive and Blanking waveforms must start at time $t_1$. Nominal Blanking times should be observed.
2. H = time from start of one line to start of next line.
3. V = time from start of one field to start of next field.
4. Video pulse width should be equal to or greater than 45 nsec.

Fig. 1 Synchronization and Blanking Generator Waveforms for the TTL Series Data Display Series.

# Section 2
# OPERATING PROCEDURES

## 2.1 INSTALLATION

Power for the TTL monitor is supplied by a self-contained power supply. 120V AC is applied to the unit via a 4 pin molex connector.

The video and synchronization signals are fed to their appropriate connections as indicated on the schematic.

Mount the monitor so that the air flow around the unit is not blocked and the ambient temperature surrounding it does not exceed 55°C.

## 2.2 GROUNDING TECHNIQUES

The method of interconnecting and grounding the equipment is a function of the signal frequency; any optimum grounding depends largely on the system in which the equipment is used.

The following grounding technique is recommended when installing a TTL Data Display Monitor.

The vertical/video, horizontal drive, vertical drive, and CRT arc bypass are all returned to the chassis plate ground. Normally, it is assumed that the frame and chassis plate of the monitor will be installed in a system where they will be an integral part of system ground. If this is true, then further grounding should not be necessary. However, the mating of the monitor's frame with the system or the generator's signal source ground must be electrically good. Good electrical metal-to-metal contact must be assured.

Where strong radiated noise and signal fields inhibit the monitor's operation or where a signal's waveform is deteriorated by long or poorly selected cabling, careful attention must be given to proper grounding of the outer conductor. Improper grounding can cause annoying ground loops and in some cases cause transistor failures.

The TTL monitor has provisions at the printed circuit board card edge connector to pick up a ground return for the vertical/video, horizontal drive, and vertical drive circuits if a separate return wire is required.

## 2.3 VIDEO LEAD ROUTING

The video lead probably will carry frequency signals and should be given the following considerations:

A. To minimize distributed capacity and capacitive pickup of nearby radiated fields, route the video leads separately and away from all other wiring.

B. Make the lead length as short as possible, consistent with the packaging requirements.

C. Ideally, the video line should meet the requirements of a terminated coaxial system; i.e., the video line should exhibit a constant impedance from source to load. An effective method of testing the video line is:

a. Establish a configuration and keep the foregoing requirements in mind.

b. Drive the source end of the video line with the output of TTL logic or an equivalent pulse generator capable of providing pulses with rise and fall times of typically 10 nanoseconds and pulse widths of approximately 100 nanoseconds. Any convenient duty cycle and repetition rate may be used. The generator should be capable of supplying +2.5 volt pulse into a shunt impedance of 3.3k ohms (resis tive) and 40 pF (capacitive).

c. Observe the pulse at the receiving end of the video line with a low capacitance (less than 5 pF) oscilloscope probe. Adjust the routing and termination of the video line to maintain rise and fall times of 20 nanoseconds or less and overshoots within 10 percent of the pulse amplitude.

## 2.4 INITIAL TURN-ON PROCEDURE

Connect the video and synchronization signals to the monitor. Apply AC power to the monitor. Adjust the brightness and contrast controls for desired effect and stabilize the picture with the vertical and horizontal hold controls.

# Section 3
# THEORY OF OPERATION

## 3.1 VIDEO AMPLIFIER

The incoming video signal of 4V P-P (typical) is applied to the monitor via pin 8. The video signal is applied through R115 to the base of Q103. Transistors Q103 and Q104 form the video amplifier stage for the monitor. Refer to figure 3-1 and schematic at rear of manual.

Transistor Q103 and its components comprise the video inverter amplifier with an adjustable gain of 12 to 25. Q103 operates as a class B amplifier. It remains cutoff until a positive going signal arrives at the base and turns Q103 on. R118 and R119 provide series feedback which makes the voltage gain relatively independent of transistor variations and stabilizes it against voltage and current changes caused by ambient temperature variations.

The negative going signal at the collector of Q103 is direct coupled to the base of Q104, an emitter follower output driver that provides a low source impedance for driving the cathode of the CRT. The class B biasing of Q104 allows more than adequate video output signal to modulate the CRT's cathode and results in a maximum available contrast ratio. Typically about 25V P-P video is required for optimum contrast.

The over-all brightness of the CRT is determined by the negative voltage at the grid and is varied by the brightness control. Normal adjustment range of CRT grid voltage is from +10 to -100VDC.

## 3.2 VERTICAL DEFLECTION AMPLIFIER

Transistor Q101 is a programmable unijunction transistor and with its external circuitry, forms a relaxation oscillator operating at the vertical rate. The sawtooth forming network consists of R106, R107, R108, C103 and C104. These capacitors charge exponentially until the voltage at the anode of Q101 exceeds its gate voltage at which time Q101 becomes essentially a closed switch allowing a rapid discharge through L101. The oscillator is synchronized by a negative pulse applied to its gate from pin 9.

A divider network consisting of R102, R103 and R104 sets the free running frequency by establishing an adjustable reference voltage at the gate. This feature programs the firing of Q101 and amounts to resistive selection of the intrinsic standoff ratio of the unijunction. The frequency is thus controlled by external elements only; it does not depend on this parameter of the unijunction. CR101 and CR102 provide temperature compensation. L101 forms a tuned circuit with C103 and C104 during conduction of Q101 that provides a stable control on the drop out time of Q101.

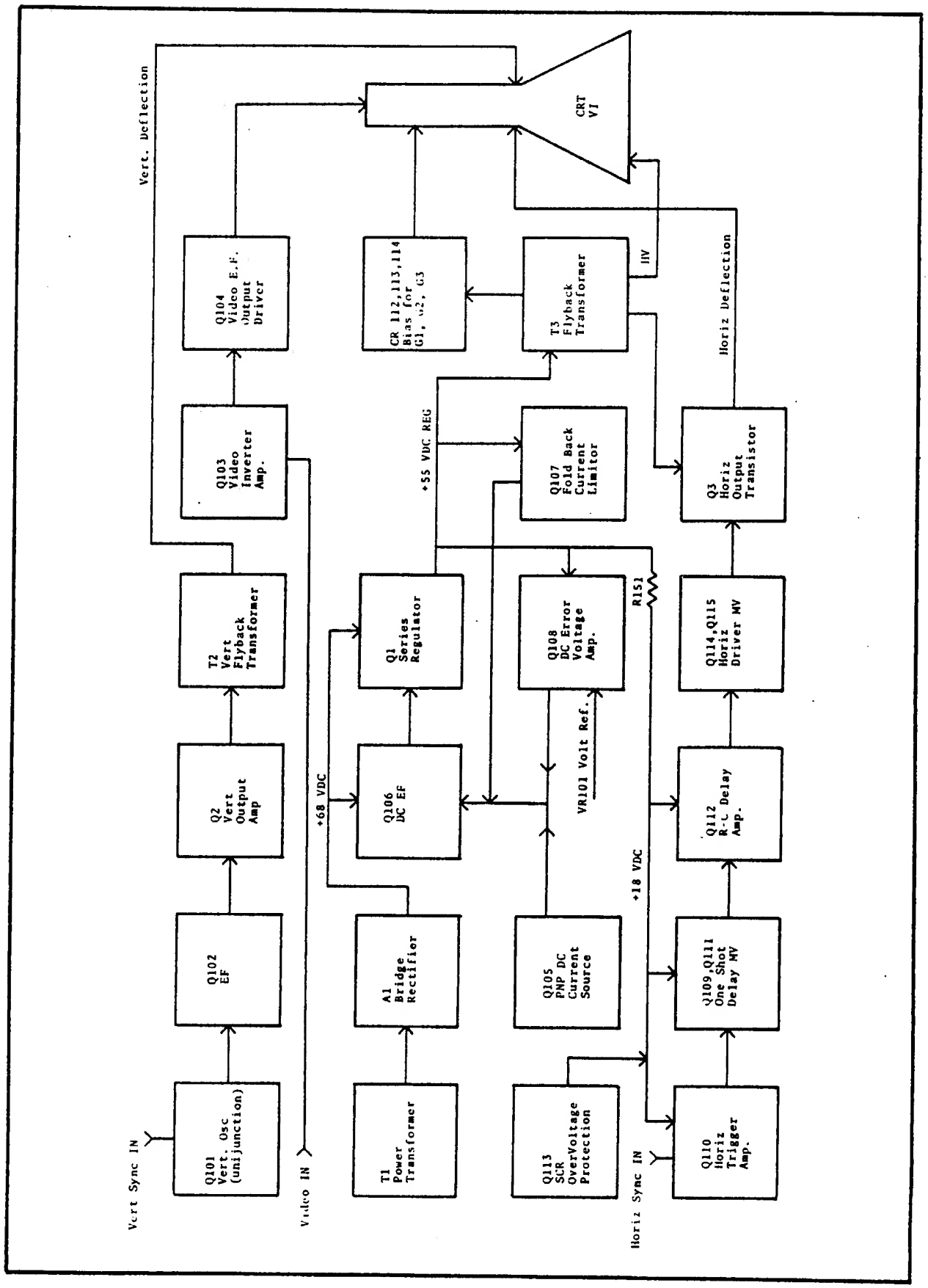



Fig. 3-1 TTL Block Diagram

The sawtooth at the anode of Q101 is directly coupled to the base of Q102. This stage functions as a darlington pair emitter follower driver for the output stage Q2. It presents an extremely high impedance in shunt with R108 and prevents the beta dependent input impedance of Q2 from affecting the frequency of the sawtooth forming network.

Linearity control of the sawtooth is accomplished by coupling the output at Q102 emitter resistively back into the junction of C103 and C104. R110, R109 and C104 integrates the sawtooth and inserts a parabolic component. The slope change rate of the sawtooth at Q102 output is controlled by the setting of R109.

Height control R107 varies the amplitude of the sawtooth voltage developed by controlling the effective B+ applied to R108 and therefore controls the vertical raster size on the CRT.

The vertical output amplifier Q1 uses a power type transistor operating as a class B amplifier. The output is transformer coupled to provide a proper impedance match with the yoke. CR103 , R113 and C107 form a clamp circuit which limits the collector voltage at Q2 to safe levels during retrace. R121 prevents oscillations by providing damping across the vertical deflection coils.

## 3.3 HORIZONTAL DEFLECTION CIRCUITS

The horizontal sync pulse must be delayed almost a full line to provide the proper timing to drive the horizontal output amplifier. Two circuits are used to create this delay: 1) a one-shot delay multivibrator Q109/Q111 and 2) the R-C delay amplifier Q112. The delayed pulse from Q112 is used to trigger the driver multivibrator (MV) Q114/Q115 at the line rate. This MV does not create any significant delay but does establish the proper time duration of approximately one-half line and the output polarity to drive the horizontal output amplifier.

The horizontal sync input signal is applied to pin 6 of the circuit card. This signal is differentiated and the positive edge of the signal is used to trigger Q110. The negative pulse at the collector of Q110 will trigger the one-shot Q109/Q111. After one half line the MV recovers and returns to its original state. The Q109 output signal is applied to Q112 through C117. This causes Q112 to generate a 15 Volt pulse at its collector. After one-third line duration,capacitor C117 discharges through CR108, R144 and R143 and terminates the output signal at Q112. The trailing edge of Q112 output signal is differentiated by C121 and is used to trigger Q114/Q115.

Q114 and Q115 are used as a one-shot driver MV. The normal state of the MV is with Q114 at saturation and Q115 at cut off. A negative going differentiated pulse from Q112 is applied to Q114. This drives Q114 to cut off, and Q115 into saturation. Q114 is held at cutoff by the feedback circuit consisting of R157, R156, C122 and CR109. After approximately one-half line duration, capacitor C122

discharges through R152 and drives Q114 into saturation. Q115 is driven to cutoff and results in a 100 Volt pulse at its collector with an additional 100V transient at the leading edge. This signal is clipped and limited to approximately 55V by R157 and CR110. It is further attenuated to 25V amplitude by resistor divider network R156 and R155. Q115 output signal is also coupled through C122 to initiate regeneration and hold Q114 in conduction until the next trigger pulse arrives.

During conduction of the driver transistor Q115 energy is stored in the coupling transformer. The voltage at the secondary is also negative so that Q3 is held at cut off. When the primary current of T101 is interrrupted due to collector cutoff of Q115 the secondary voltage reverses polarity. Q3 goes into conduction due to the positive signal at its base. The collector current of Q3 will slowly increase in a sawtooth pattern during the remaining period of the TV line scan. Typically the peak sawtooth current through Q3 will be two to three amps depending upon line rate and length of TV line scan.

The horizontal output stage has three main functions: to supply the yoke with the correct horizontal scanning currents; develop 17kV for the CRT anode and to develop +800V and -100V for the CRT supply voltages.

Horizontal output transistor Q3 acts as a switch which is turned on and off by the rectangular waveform on the base. When Q3 is turned on, the supply voltage plus the charge on the C135 causes yoke current to increase in a linear manner and moves the beam from near the center of the screen to the right side. At this instant, the transistor is turned off by a negative voltage on its base which causes the output circuit to complete one half cycle of sine wave oscillation. A positive flyback voltage pulse of several microseconds duration and several hundred volts amplitude in the form of a half cycle sine wave pulse is developed by the combined inductance of the yoke, T3 and C127. The peak magnetic energy which was stored in the yoke during scan time is then transferred to C127 and the yoke's distributed capacity. During this cycle, the beam is returned to the center of the screen.

C127 and the distributed capacity now discharge into the yoke and induce a current in a direction opposite to the current of the previous part of the cycle. The magnetic field thus created around the yoke moves the beam to the left of the screen.

After one half cycle, the voltage across C127 swings below ground potential and biases the damper diode CR116 into conduction and prevents the flyback pulse from oscillating. The magnetic energy that was stored in the yoke from the discharge of the distributed capacity and C127 is released to provide sweep for the first half of the scan and to charge C135 through the rectifying action of the damper diode. The beam is then at the center of the screen. The cycle will recur when the base voltage of Q3 is driven positive again.

C135 also serves to block DC currents through the yoke and provide "S" shaping of the current waveform. "S" shaping compensates for stretching at the left and right sides of the CRT. The width sleeve inserted between the yoke and CRT also provides partial linearity correction at the beginning of the horizontal scan.

L104 is an adjustable width control placed in series with the horizontal deflection coils. This variable inductor allows a greater or lesser amount of the deflection current to flow through the horizontal yoke and varies the width of the horizontal scan.

The positive flyback pulse developed during the horizontal retrace time is rectified by CR114 and filtered by C125. This produces approximately 600 volts and is coupled through the focus control R167 to G3 of the CRT. CR112, CR113, C123 and C124 comprise a voltage doubler which delivers approximately 1000 volts to a divider network of R163 and R170. This divider provides approximately 800 volts for G2 of the CRT. This same pulse is transformer-coupled to the secondary of transformer T2 where it is rectified by CR1 and CR115 to produce rectified voltages of approximately 17kV and -100 volts. The 17kV is the anode voltage for the CRT. The -100 volts serves as the source voltage for the brightness control R165 or an external brightness control.

The collector voltage for Q109, Q110, Q111 and Q112 is obtained by dropping the +55 volt supply down to approximately +20 volts by the use of the series dropping resistor R151. The use of a separate lower supply bus provides a means of automatic shut down in the event of an over voltage condition which might generate X-rays and protection of random drive pulses to the horizontal output transistor during "turn on" or "turn off" of the monitor.

Protection against X-rays due to over voltage operation of the line or DC regulator circuits is provided by Q113, VR102 and associated components. In the event the +55 VDC regulator circuit should fail and the output voltage exceed approximately 60 volts, the voltage developed by resistor divider network R147, R148 and R149 will increase also. This increased voltage will cause current conduction through VR102 and R150. The voltage developed across R150 will cause Q113 to fire so that the heavy current will flow from anode to cathode to discharge capacitor C118 and drop the entire supply voltage across R151. This will disable the low level MV's and consequently disable the horizontal output stage and the associated high voltage supply.

This separate supply bus also provides protection against random drive pulses to the horizontal output transistor during "turn on" or "turn off". Normally several AC cycles are required after "turn on" to bring the +55 VDC bus up to normal. By virtue of the component values selected for Q109, Q111 and series dropping resistor R151, Q109 and Q111 would not trigger until the regulator voltage exceeds approximately +30 volts. This DC supply is adequate to provide stable operation of the horizontal circuit and base drive to the horizontal output amplifier so that random drive pulses and poor

collector saturation of Q3 are avoided.

During "turn off" this separate supply bus also offers some degree of protection against CRT spot burn. After AC power is turned off power supply filter capacitor C3 is rapidly discharged by the load current so that the +55 VDC regulator output decays rapidly to 30 volts. Below this level Q109 and Q111 will fail to trigger. As a result the horizontal output transistor and associated HV circuitry are disabled. This will result in a reduction of discharge current from the power supply filter C3 to approximately one third its former rate.

The energy retained by C3 will also be used mainly by the vertical deflection circuit for a significently longer period of operation. The energy of the CRT beam will then be distributed along the vertical axis of the CRT to prevent spot burn while the HV stored in the CRT aquadag is discharged.

## 3.4 LOW VOLTAGE REGULATED SUPPLY

The AC line voltage is applied through a molex connector to the primary windings of transformer T1 which is located on the power supply module.

The secondary windings illustrated at the bottom of T1 is used to supply 6.3 VAC filament voltage. The other winding is used to apply an AC voltage to A1 so that approximately +68 volts is developed across C3.

The +68 volts is dropped to +55 volts by the series regulator Q1. DC regulation of +55 volts is maintained by tapping down the voltage through divider network R133, R134, and R135. Approximately +7 volts at the center tap of R134 is applied to the base of Q108. Also a DC reference voltage from VR101 is applied to the emitter of Q108. This transistor then developes a DC error current which flows through R130 to the base of emitter follower Q106. A DC bias current is supplied to the base of Q106 and the collector of Q108 by Q105 which is used as a DC current generator. The bias current from Q105 will tend to shift the base of Q106 in a positive direction whereas the current from Q108 will tend to shift the base in the negative direction. This results in an error current from the collector of Q108 that controls emitter follower Q106 and also the series pass transistor Q1. The result is that the DC output voltage is maintained at +55 VDC with various load currents and variations of the input AC voltage.

Fold-back current limiting of the +55 VDC supply is provided by means of transistor Q107, resistor R127, R128 and R129. The DC bias current flowing down through R127 and R129 to ground provides a DC drop of approximately 2.4 volts across R127. The DC load current flowing through R128 will provide a voltage drop across this resistor so that the drop is proportional to the load current. If this load current exceeds 2.4A, the emitter of Q107 will be biased approximately 3 volts below the emitter of Q1, assuming that voltage drop of 2.4V across R128 and .6 volts across CR106. In as much

the base of Q107 is biased at 2.4 volts below the emitter of Q1, Q107 will conduct so that the voltage drop across Q105 is increased and the DC output voltage of the supply will decrease below +55 volts. This will limit peak current to approximately 2.4 amperes. In the event of a direct short on the +55 VDC bus, the output voltage will drop to approximately zero and the short-circuit current will be limited to approximately 100MA. Clearing or removing the external short-circuit will allow the regulator to resume normal circuit operation. The average current through Q1 is approximately one half ampere, however the combined peak currents of the horizontal and vertical deflection circuits may be much greater than this even though electrolytic capacitors are used across the +55 volt bus.

# Section 4

# PRELIMINARY ADJUSTMENTS

## 4.1 SYNCHRONIZATION AND DRIVE SIGNALS

Apply horizontal and vertical drive signals to the horizontal and vertical drive terminals as indicated on the schematic. Adjust the levels to a nominal 4 volt peak-to-peak.

The horizontal drive signal is required to initiate horizontal scan and high voltage, and should be connected before applying power to the monitor.

## 4.2 LOW VOLTAGE SUPPLY

Connect a voltmeter between ground and junction of R131 and CR106 cathode. Adjust the B+ voltage control R134 for a reading of 55V.

## 4.3 BRIGHTNESS

Normally, the monitor will be used to display alphanumeric or other black and white information. Normally the video polarity is usually white characters on a black background.

The brightness control should be adjusted to a point where the white raster is just extinguished. The CRT will then be at its cutoff point, and a maximum contrast ratio can be obtained when a video signal is applied.

## 4.4 VIDEO CONTRAST

Q103 is designed to operate linearly when a +2.5V signal is applied to its base. An external contrast control (500Ω) is used to maintain this level. This control should be adjusted for a typical signal level of +2.5V peak-to-peak when measured at the video input terminal of the board edge connector. The video gain control R119 should be adjusted for optimum contrast or detail while observing the CRT.

## 4.5 VERTICAL ADJUSTMENTS

There is a slight interaction among the vertical frequency, height, and linearity controls. A change in the height of the picture may affect linearity. Consequently the adjustment should be carried out in the following sequence:

(1) Apply video and synchronization signals to the monitor.

(2) Set the vertical hold control, R103, near the mechanical center of its rotation.

(3) Adjust the vertical height control R107 for desired height.

(4) Adjust the vertical linearity control R109 for best vertical linearity.

(5) Remove the vertical drive signal from the unit or use a short jumper lead and short the vertical drive input terminal of the board edge connector to ground.

(6) Readjust the vertical hold control R103 until the picture rolls down slowly.

(7) Restore vertical drive to the monitor and check height and linearity.

## 4.6 HORIZONTAL ADJUSTMENTS

Raster width is affected by a combination of the low voltage supply, width coil L104, and the width sleeve located on the neck of the CRT beneath the yoke.

(1) Apply video and sync signals to the monitor.

(2) Adjust the horizontal width coil L104 for the desired width.

(3) Insert the width sleeve farther under the yoke to obtain the best linearity. Although this adjustment will affect the raster width, it should not be used solely for that purpose. It should be inserted only as far as required for adequate linearity correction, otherwise excessive current will be drawn by the horizontal output amplifier.

(4) Readjust L104 for proper width.

(5) Observe final horizontal linearity and width, and touch up either adjustment if needed.

No horizontal hold control is used in this monitor. The raster should be properly locked and can be centered with the video centering control R143.

## 4.7 FOCUS ADJUSTMENT

The focus control, R165, provides an ajustment for maintaining best over-all display focus.

## 4.8 CENTERING

If the raster is not properly centered, it may be repositioned by rotating the ring magnets behind the deflection yoke. The magnets should not be used to offset the raster from its nominal center position because it would degrade the resolution of the display. If the picture is tilted, rotate the entire yoke.

# Section 5

# TROUBLE SHOOTING AND MAINTENANCE

## 5.1 ISOLATION OF CIRCUIT FAULTS

In the event of failure or malfunction of the monitor there is a sequence of simple steps which can be carried out to isolate the fault to a particular circuit area. The first thing to check is the +55 VDC bus. In the event of a short circuit the voltage regulator will "foldback" to limit the current. In the event of a direct short the DC voltage will decay to zero. In other situations excessive load current will cause the regulator to "fold back" and then "start up" again. This cycle may reoccur at a relatively high rate such as a thousand times per second which is probably due to attempting to energize a faulty horizontal output stage. A low audible buzz may often be heard. This "fold back" and "restart" of the regulator may also occur at a much lower rate such that it appears to be synchronized with the vertical rate. This probably would be due to excessive pulse current drawn by the vertical output deflection amplifier. Isolation of faulty circuit blocks may be done as follows:

(1) Disconnect Molex connector to J104 to isolate the vertical output stage.

(2) Disconnect Molex connector to J110 to isolate the flyback transformer and horizontal output transistor stage.

NOTE: Removal of connector at J110 will open circuit the "ground" wire conductor to chassis. Use short "alligator clip lead" between chassis and case of aluminum filter capacitor C3 in power supply module to reestablish ground connection.

Removal of the above two circuit blocks should reduce load current on the +55 VDC regulator to a fraction of the former value. Failure of the regulator to perform normally should probably be attributed to a shorted electrolytic capacitor on the board or defective components in the regulator circuit.

Actual isolation of a fault to a single transistor stage is best accomplished by use of a scope and reference to typical waveforms contained in this section. The most critical tests or waveforms of the horizontal output stages are:

(1) Driver transformer (T101) primary waveform
(2) Horizontal flyback pulse at Q3-C
(3) Radiated pulse from flyback transformer T3 (Hold a 10:1 scope probe approximately 2" away from the HV flyback transformer).
(4) Check parabolic waveform voltage across "s" shaping capacitor C135.
(5) Measure DC current to horizontal output amplifier by measuring voltage drop across R168. Typical current of .25 A DC should generate a voltage drop of .3 volt DC. Current on high line rate models should run somewhat higher.

(6) "Tearing" of raster may be due to "over Voltage" adjustment of the +55 VDC regulator. This may cause erratic "firing" of the SCR transistor Q113. Absence of drive signals to horizontal output stage may be due to complete shut down of SCR Q113.

Tests on the power transistor circuits located on the PC board can be carried out by the use of scope and reference to typical voltage waveforms.

Typical waveforms are illustrated by section 5.2. Waveforms of high line rate models are similar with the time duration of the waveforms will be somewhat less, i.e. they should be scaled in time such that they are proportional to the time of a horizontal line. The amplitude of the horizontal flyback pulse should be somewhat less due to lower values of yoke inductances. Waveforms which occur at field rate should be similar. Figure 5-1 illustrates the component location and the location of the molex connectors and wire color codes.

Waveforms which occur at field rate were taken with the scope externally synchronized to the leading edge of vertical drive. In the case of waveforms at horizontal line rate the scope was synchronized to the leading edge of horizontal drive, consequently the time relationship of each waveform actually indicates the relative time delay of each multivibrator. In most cases, the scope was DC coupled when the waveforms were taken so that the relative position of ground potential on the waveforms could be indicated.

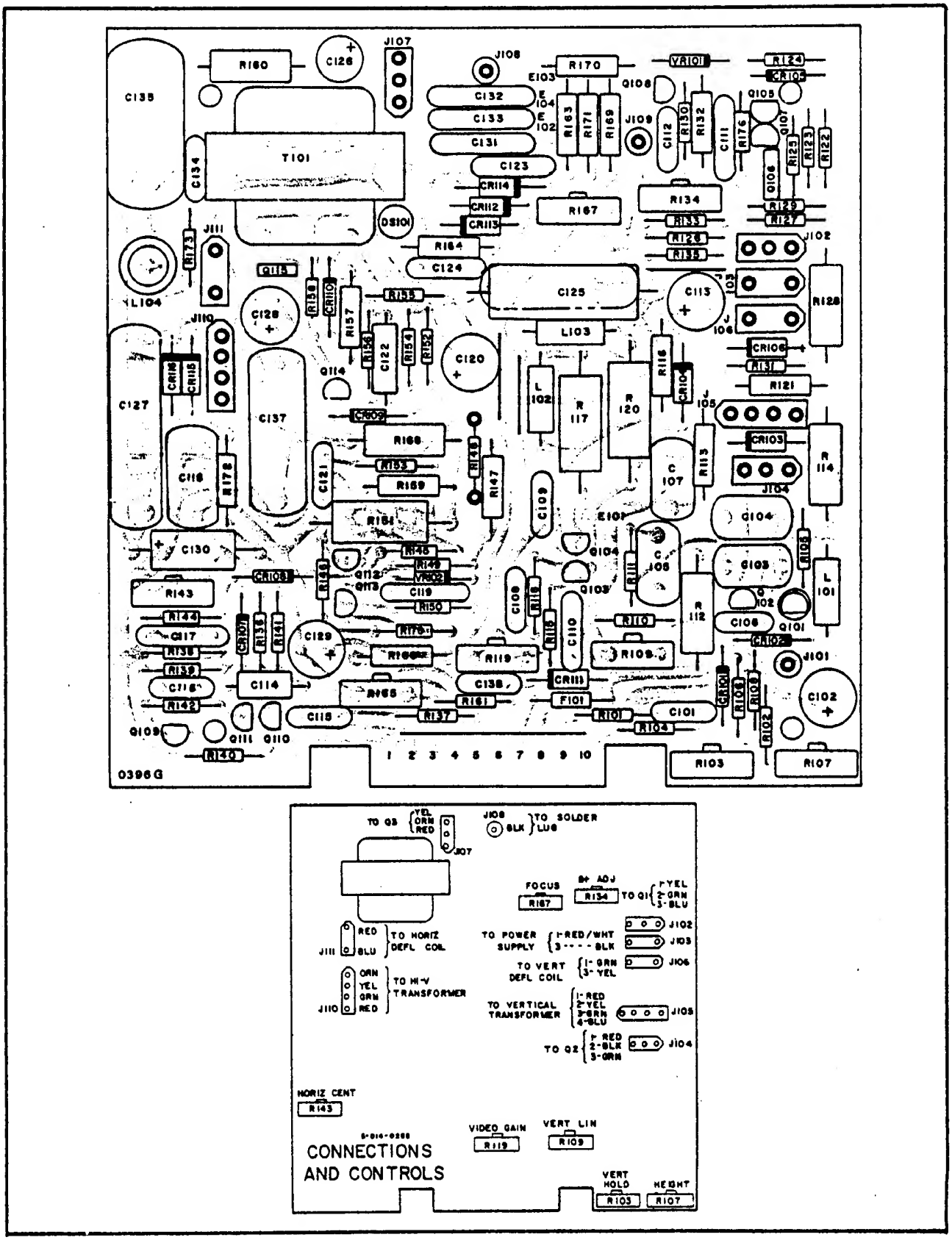
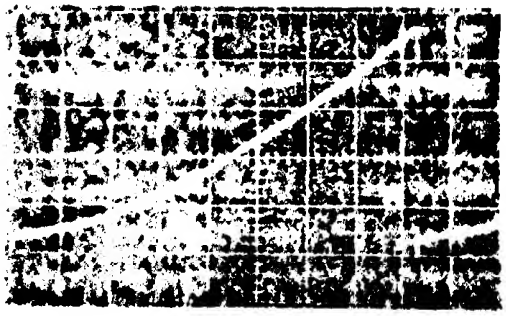



Fig. 5-1 Circuit Board Component Location and Intercabling Diagram.

## 5.2 TYPICAL WAVEFORMS

Q101-anode
Field Rate
1V/Div

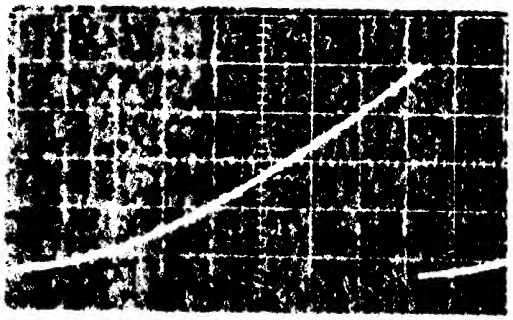
Ground Ref. →



#1

Q2-Base
Field Rate
1V/Div

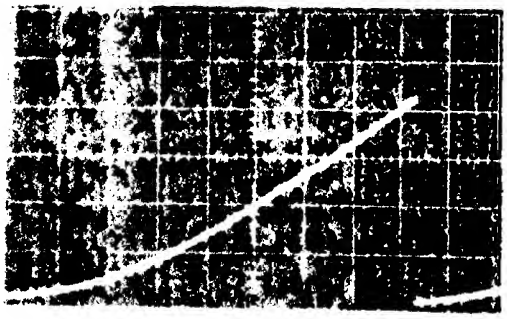
Ground Ref. →



#2

Q2-Emitter
Field Rate
1V/Div

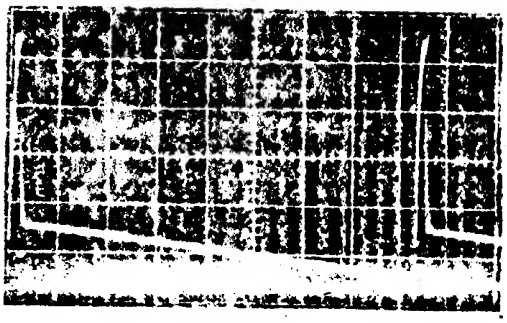
Ground Ref. →



#3

Q2-Collector
Field Rate
50V/Div

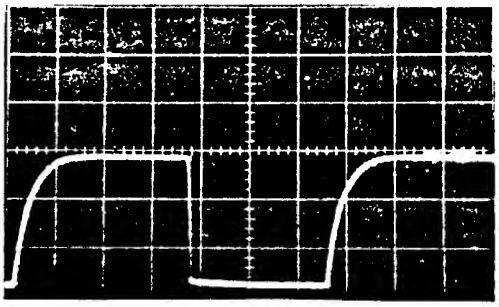
Ground Ref. →



#4

Q109-Collector
Line Rate
5V/Div

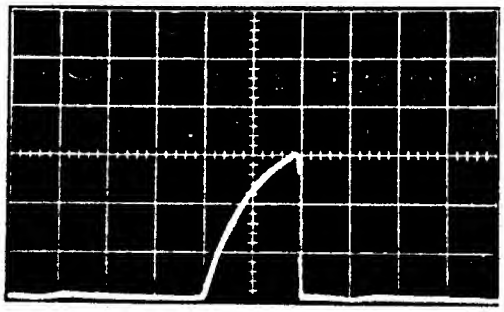
Ground Ref. ⟶



#5

Q112-Collector
Line Rate
5V/Div

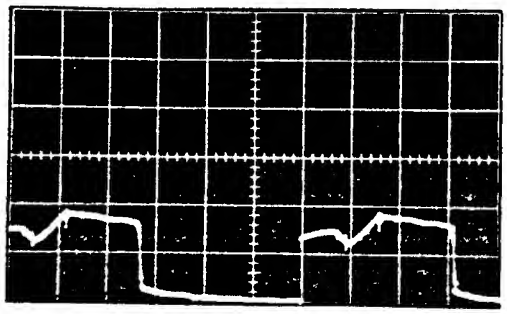
Ground Ref. ⟶



#6

Q114-Collector
Line Rate
.5 Volt/Div

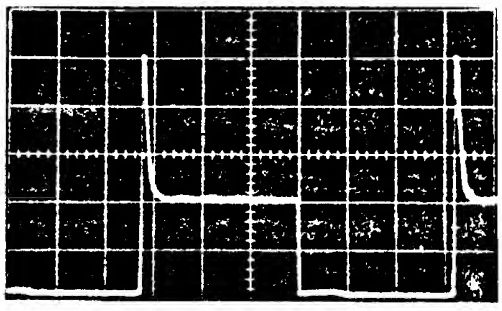
Ground Ref. ⟶



#7

Q115-Collector
Line Rate
50V/Div

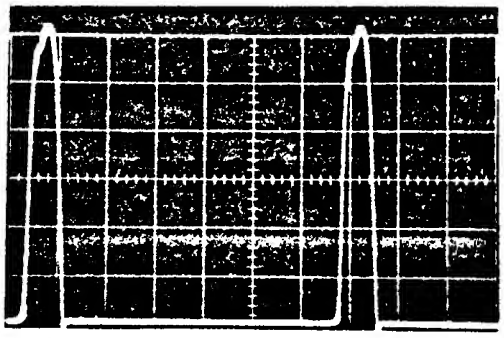
Ground Ref. ⟶



#8

Q3-Collector
(Horiz. Flyback Pulse)
Line Rate
100V/Div

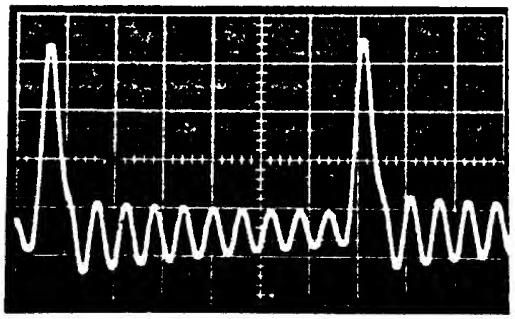
Ground Ref. ⟶



#9

Radiated Pulse from
flyback Transformer. 10:1
Probe held 2" away
Line Rate
50V/Div

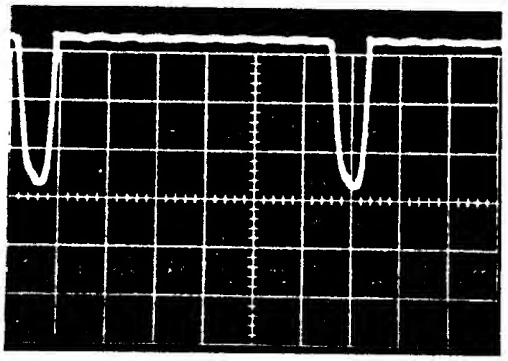
Scope AC
Coupled



#10

Ground Ref. ⟶

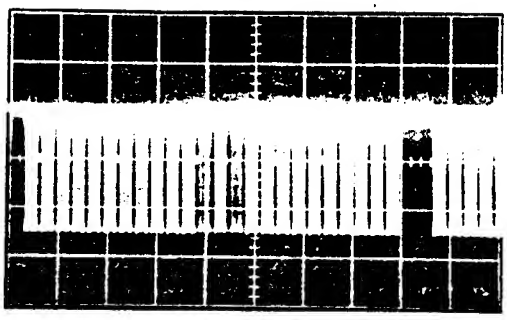
CR115 Cathode
Line Rate
50V/Div



#11

CRT Cathode
Line Rate
10V/Div

Ground Ref. ⟶



#12

Section 6

TTL Parts List

| SYMBOL | | DESCRIPTION | BBRC PART NUMBER |
|---|---|---|---|
| A1 | | Bridge Rectifer, VS148 | 1-021-0413 |
| | | CAPACITOR, fixed; µF unless otherwise stated | |
| C1 | | .001 ± 10%; 1000V, ceramic disc | 1-012-0540 |
| C2 | | .01; 1000V, arc gap ceramic | 1-021-0112 |
| C3 | | 1400; 90V, electrolytic | 1-012-2186 |
| C101 | | .001 ± 10%; 1000V, ceramic disc | 1-012-0540 |
| C102 | | 50; 50V, electrolytic | 1-012-2157 |
| C103 | | .22 ± 10%; 200V, mylar | 1-012-0930 |
| C104 | | .22 ± 10%; 200V, mylar | 1-012-0930 |
| C105 | | .22 ± 10%; 200V, mylar (TTL15/AM, TTL15/C, TTL15/875, TTL15/1029) | 1-012-0930 |
| C106 | | .001 ± 10%; 1000V, ceramic disc (TTL15/AM, TTL15/C, TTL15/875, TTL15/1029). | 1-012-0540 |
| C107 | | .1 ± 10%; 400V, mylar | 1-012-2239 |
| C108 | | 250pF ± 5%; 500V, dipped mica | 10-57-5251 |
| | or | 180pF ± 5%; 500V, dipped mica (TTL15/C, TTL15/875, TTL15/1029) | 10-57-5181 |
| C109 | | 100pF ± 5%; 500V, dipped mica | 1-012-0300 |
| C110 | | .1 ± 20%; 100V, ceramic disc | 10-12-7104 |
| C111 | | .1 ± 20%; 100V, ceramic disc | 10-12-7104 |
| C112 | | 27pF ± 5%; dipped mica | 1-012-2161 |
| C113 | | 5; 150V, electrolytic | 1-012-2195 |
| C114 | | .0039 ± 10%; 200V, mylar | 10-47-7392 |
| | or | .0033 ± 10%; 200V, mylar (TTL15/AV) | 10-47-7332 |
| | or | .0022 ± 10%; 200V, mylar (TTL15/C, TTL15/875) | 10-47-7222 |
| | or | .0018 ± 10%; 200V, mylar (TTL15/AM) | 10-47-7182 |
| | or | .0015 ± 10%; 200V, mylar (TTL15/1029) | 10-47-7152 |
| C115 | | .001 ± 10%; 1000V, ceramic disc | 1-012-0540 |
| C116 | | 22pF ± 5%; 500V, dipped mica | 10-57-5220 |
| C117 | | 750pF ± 5%; 100V, dipped mica | 10-57-5751 |
| C118 | | .47 ± 10%; 200V, mylar | 1-012-1927 |
| C119 | | .1 ± 20%; 100V, ceramic disc | 10-12-7104 |
| C120 | | 5; 150V, electrolytic | 1-012-2195 |
| C121 | | .001 ± 10%; 1000V, ceramic disc | 1-012-0540 |
| | or | .002 ± 10%; 500V, ceramic disc (TTL15/AM) | 10-16-7208 |
| C122 | | .0082 ± 10%; 200V, mylar | 10-47-7822 |
| | or | .0022 ± 10%; 200V, mylar (TTL15/AM, TTL15/C, TTL15/1029, TTL15/875) | 10-47-7222 |
| C123 | | .01 ± 20%; 1000V, ceramic disc | 1-012-2214 |
| C124 | | .02 ± 20%; 1000V, ceramic disc | 1-012-2217 |
| C125 | | .015 ± 10%; 1000V, film/paper | 1-012-2201 |
| | or | .1 ± 10%; 600V, mylar (TTL15/1029) | 1-012-2202 |
| C126 | | 25; 25V, electrolytic | 1-012-2212 |
| | or | 10; 25V, electrolytic (TTL15/AM, TTL15/C, TTL15/1029, TTL15/875) | 1-012-2211 |

| SYMBOL | | DESCRIPTION | BBRC PART NUMBER |
|---|---|---|---|
| C127 | | .0056 ± 10%; 2000V, mylar | 10-35-7562 |
| | or | .005 ± 10%; 1600V, mylar (TTL15/0) | 1-012-2232 |
| | or | .0068 ± 10%; 1600V, mylar (TTL12) | 1-012-2210 |
| C128 | | 5; 150V, electrolytic | 1-012-2195 |
| C129 | | 5; 150V, electrolytic | 1-012-2195 |
| C130 | | 1; 150V, electrolytic | 1-012-2168 |
| C131 | | .01; 1000V, arc cap, ceramic | 1-012-0112 |
| C132 | | .01; 1000V, arc cap, ceramic | 1-012-0112 |
| C133 | | .01; 1000V, arc cap, ceramic | 1-012-0112 |
| C134 | | .001 ± 10%; 1000V, ceramic disc | 1-012-0540 |
| C135 | | 1.5 ± 10%; 100V, polycarbonate | 1-012-2216 |
| C136 | | 2pF; 250V, arc cap | 1-012-0111 |
| C137 | | 1 ± 10%; 100V, mylar | 1-012-1025 |
| C138 | | 250pF ± 5%; 500V, dipped mica | 10-57-5251 |
| | | DIODE | |
| CR101 | | 1N3605 | 1-021-0410 |
| CR102 | | 1N3605 | 1-021-0410 |
| CR103 | | 1N3280 | 1-021-0403 |
| CR104 | | 1N628 | 1-021-0160 |
| CR105 | | 1N3605 | 1-021-0410 |
| CR106 | | 1N4001 | 78-62-4001 |
| CR107 | | 1N3605 | 1-021-0410 |
| CR108 | | 1N3605 | 1-021-0410 |
| CR109 | | 1N3605 | 1-021-0410 |
| CR110 | | 1N628 | 1-021-0160 |
| CR111 | | 1N3280 | 1-021-0403 |
| CR112 | | 1N3280 | 1-021-0403 |
| CR113 | | 1N3280 | 1-021-0403 |
| CR114 | | VG-1X | 1-021-0447 |
| CR115 | | 1N3280 | 1-021-0403 |
| CR116 | | 1N5398 | 1-021-0436 |
| CR1 | | RHC-25-20 | 1-021-0438 |
| DS101 | | NO. 1764 | 1-026-0308 |
| | | FUSE | |
| F1 | | 3/4A-125 | 1-028-0242 |
| | or | 1A-125 | 28-13-0100 |
| F2 | | 2A-125V | 1-028-0249 |
| | | COIL | |
| L1 | | Deflection coil assembly | 6-004-0323 |
| | or | Deflection coil assembly (TTL15/0) | 6-004-0676 |
| | or | Deflection coil assembly (TTL12) | 6-004-0350 |
| | or | Deflection coil assembly (TTL15C) | 6-004-0347 |
| | or | Deflection coil assembly (TTL15/1029) | 6-004-0328 |
| | or | Deflection coil assembly (TTL15/875) | 6-004-0336 |
| | or | Deflection coil assembly (TTL15/AM) | 6-004-0354 |

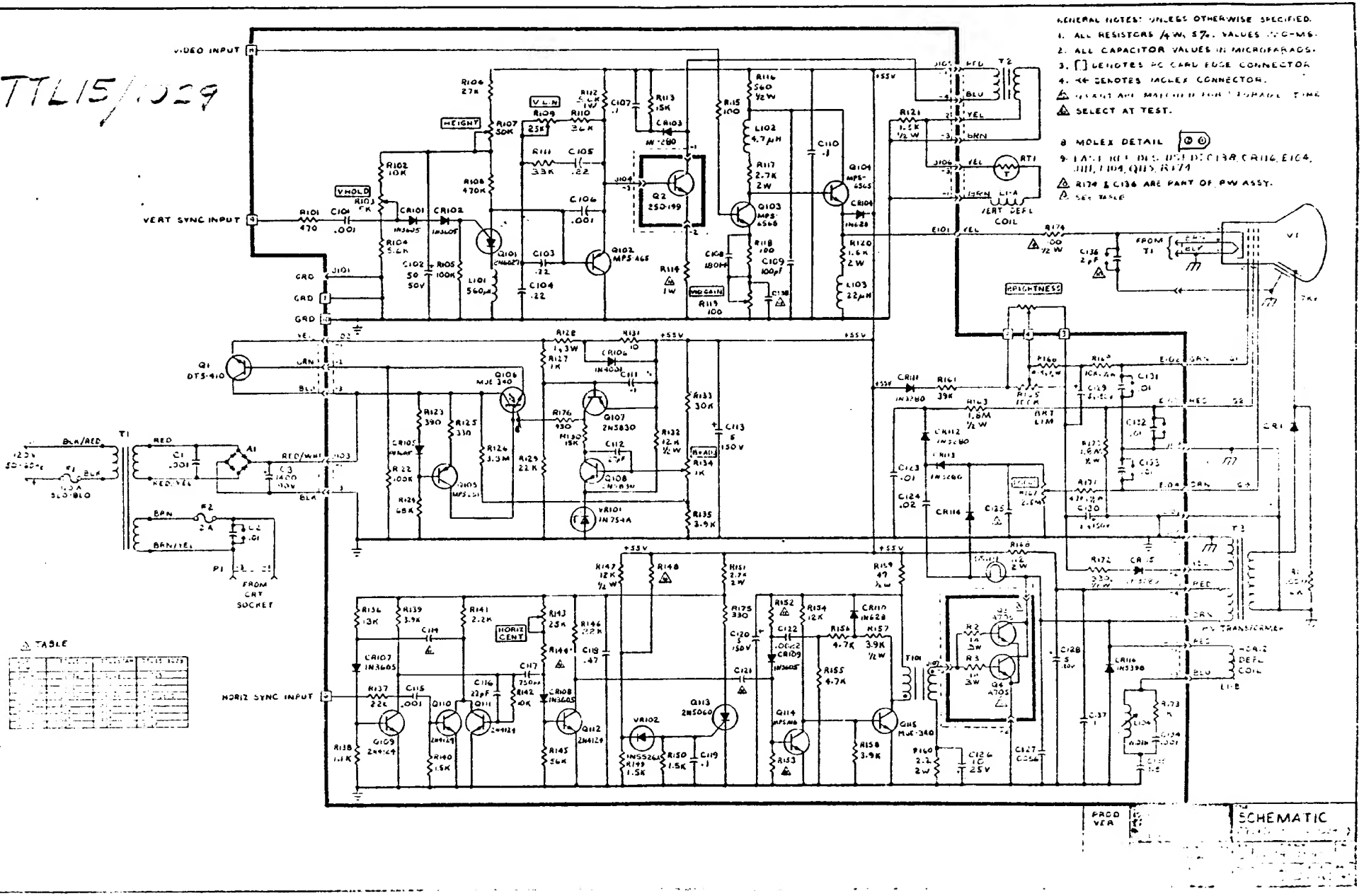
| SYMBOL | | DESCRIPTION | BBRC PART NUMBER |
|---|---|---|---|
| L2 | | 10μH | 15-13-1100 |
| L101 | | 560μH | 1-016-0302 |
| L102 | | 4.7μH | 15-13-1479 |
| L103 | | 22μH | 15-13-1220 |
| L104 | | Width Coil | 1-016-0304 |
| | or | Width coil (TTL15/0) | 1-016-0309 |
| | or | Width coil (TTL15/AM, TTL15/C, TTL15/1029, TTL15.875) | 1-016-0299 |
| | | TRANSISTOR | |
| Q1 | | DTS-410 | 78-85-0410 |
| Q2 | | 2SD-199 | 1-015-1176 |
| Q3 | | DTS-402 (525) | 78-85-0402 |
| | or | DTS-802 (TTL15/875) | 1-015-1189 |
| | or | A705 (TTL15/0) | 78-85-0709 |
| Q4 | | A705 | 78-85-0709 |
| Q101 | | 2N6027 | 1-015-1157 |
| Q102 | | MPS-A65 | 1-015-1186 |
| Q103 | | MPS-6565 | 1-015-1185 |
| Q104 | | MPS-6565 | 1-015-1185 |
| Q105 | | MPS-L51 | 1-015-1175 |
| Q106 | | MJE-340 | 78-86-0340 |
| Q107 | | 2N5830 | 1-015-1172 |
| Q108 | | 2N5830 | 1-015-1172 |
| Q109 | | 2N4124 | 1-015-1139 |
| Q110 | | 2N4124 | 1-015-1139 |
| Q111 | | 2N4124 | 1-015-1139 |
| Q112 | | 2N4124 | 1-015-1139 |
| Q113 | | 2N5060 | 1-015-1168 |
| Q114 | | MPS-A16 | 1-015-1193 |
| Q115 | | MJE-340 | 78-86-0340 |
| | | RESISTOR fixed film: ¼W ± 5% unless otherwise stated | |
| R1 | | 500M; 6W, deposited carbon (AA version) | 1-011-1800 |
| | or | 500M; 6W, deposited carbon (BB version) | 1-011-2456 |
| R2 | | 1Ω ± 10%; 3W, wirewound | 1-011-1742 |
| R3 | | 1Ω ± 10%; 3W, wirewound | 1-011-1742 |
| R101 | | 470Ω | 70-16-0471 |
| R102 | | 470Ω | 70-16-0471 |
| | or | 10K (TTL15/AM, TTL15/C, TTL15/1029, TTL15/875) | 70-16-0103 |
| R103 | | Var; 10K ± 20%; 1/8W, composition, vertical hold | 1-011-5312 |
| | or | Var; 5K ± 20%; 1/8W, composition, vertical hold (TTL15/1029, TTL15/AM, TTL15/C, TTL15/875) | 1-011-5637 |
| R104 | | 6.8K | 70-16-0682 |
| R105 | | 100K | 70-16-0104 |
| R106 | | 27K | 70-16-0273 |
| R107 | | Var; 50K ± 20%; 1/8W, composition, vertical height | 1-011-5373 |
| R108 | | 220K | 70-16-0224 |
| | or | 470K (TTL15/AM, TTL15/C, TTL15/875, TTL15/1029) | 70-16-0474 |

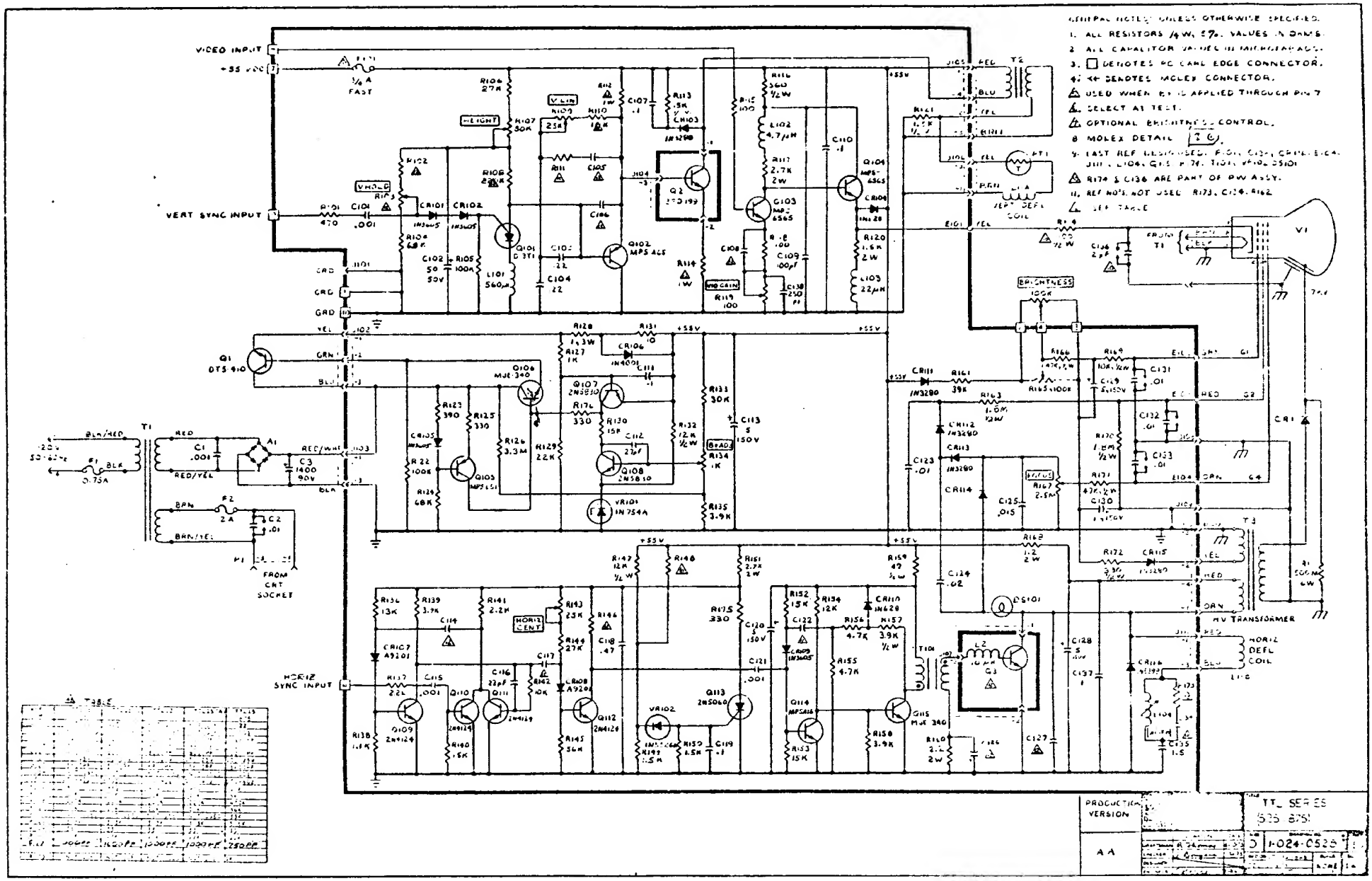
| SYMBOL | | DESCRIPTION | BBRC PART NUMBER |
|---|---|---|---|
| R109 | | Var; 25K ± 20%; 1/8W, composition, vertical lin. | 1-011-5325 |
| R110 | | 10K | 70-16-0103 |
| | or | 36K (TTL15-AM, TTL15/C, TTL15/875, TTL15/1029) | 70-16-0363 |
| R111 | | 33K (TTL15/AM, TTL15/C, TTL15/875, TTL15/1029) | 70-16-0333 |
| R112 | | 3.3K; 1W, composition | 1-011-2425 |
| | or | 5.6K; 1W, composition (TTL15/AM, TTL15/C, TTL15/875, TTL15/1029) | 1-011-2444 |
| R113 | | 15K | 70-16-0153 |
| R114 | | 33Ω; 1W, composition | 1-011-2426 |
| | or | 22Ω; 1W, composition (TTL15/AM, TTL15/C) | 1-011-2421 |
| | or | 15Ω; 1W, composition (TTL15/875, TTL15/1029) | 78-15-0150 |
| R115 | | 100Ω | 70-16-0101 |
| R116 | | 560Ω; ½W | 1-011-2264 |
| R117 | | 2.7K; 2W, composition | 1-011-2420 |
| R118 | | 100Ω | 70-16-0101 |
| R119 | | Var; 100Ω ± 20%; 1.8W, composition, video gain | 1-011-5095 |
| R120 | | 1.5K; 2W, composition | 1-011-1500 |
| R121 | | 1.5K; ½W | 1-011-2274 |
| R122 | | 100K | 70-16-0104 |
| R123 | | 390Ω | 70-16-0391 |
| R124 | | 68K | 70-16-0683 |
| R125 | | 330Ω | 70-16-0331 |
| R126 | | 3.3M | 70-16-0335 |
| R127 | | 1K | 70-16-0102 |
| R128 | | 1Ω ± 10%; 3W, wirewound | 1-011-1742 |
| R129 | | 22K | 70-16-0223 |
| R130 | | 15K | 70-16-0153 |
| R131 | | 10Ω | 70-16-0100 |
| R132 | | 12K; ½W | 1-011-2296 |
| R133 | | 30K | 70-16-2296 |
| R134 | | Var; 1K ± 20%; 1/8Wc compsition, B+ adjust | 1-011-5182 |
| R135 | | 3.9K | 70-16-0392 |
| R136 | | 13K | 70-16-0133 |
| R137 | | 2.2K | 70-16-0222 |
| R138 | | 1.1K | 70-16-0112 |
| R139 | | 3.9K | 70-16-0392 |
| R140 | | 1.5K | 70-16-0152 |
| R141 | | 2.2K | 70-16-0222 |
| R142 | | 10K | 70-16-0103 |
| R143 | | Var; 25K ± 20%; 1/8W, composition, horizontal centering | 1-011-5325 |
| R144 | | 27K | 70-16-0273 |
| | or | 22K (TTL15/1029, TTL15/875) | 70-16-0223 |
| R145 | | 56K | 70-16-0563 |
| R146 | | 22K | 70-16-0223 |
| R147 | | 12K; ½W | 1-011-2296 |
| R148 | | Selected | |
| R149 | | 1.5K | 70-16-0152 |

| SYMBOL | | DESCRIPTION | BBRC PART NUMBER |
|---|---|---|---|
| R150 | | 1.5K | 70-16-0152 |
| R151 | | 2.7K; 2W, composition | 1-011-2420 |
| R152 | | 15K | 70-16-0153 |
| | or | 22K (TTL15C, TTL15/AM, TTL15/875) | 70-16-0223 |
| | or | 20K (TTL15.1029) | 70-16-0203 |
| R153 | | 15K | 70-16-0153 |
| | or | 8.2K (TTL15/1029) | 70-16-0822 |
| R154 | | 12K | 70-16-0123 |
| R155 | | 4.7K | 70-16-0472 |
| R156 | | 4.7K | 70-16-0472 |
| R157 | | 3.9K; ½W | 1-011-2284 |
| R158 | | 3.9K | 70-16-0392 |
| R159 | | 47Ω; ½W | 1-011-2238 |
| R160 | | 2.2Ω; 2W, wirewound | 1-011-0120 |
| R161 | | 39K | 70-16-0393 |
| R162 | | Not used | |
| R163 | | 1.8M; ½W | 1-011-2348 |
| R164 | | 100Ω; ½W (used model without DS201) | 1-011-2246 |
| R165 | | Var; 100K ± 20%; 1/8W, composition brightness (optional) | 1-011-5435 |
| R166 | | 47K; ½W | 1-011-2310 |
| R167 | | Var; 2.5M ± 20%; 1/8W, composition focus | 1-011-5566 |
| R168 | | 1.2Ω; 2W, wirewound | 1-011-1395 |
| R169 | | 10K; ½W | 1-011-2294 |
| R170 | | 1.8M; ½W | 1-011-2348 |
| R171 | | 47K; ½W | 1-011-2310 |
| R172 | | 330, ½W | 1-011-2258 |
| R173 | | 1K (875) | 70-16-0102 |
| R174 | | 100Ω; ½W | 1-011-2246 |
| R175 | | 330Ω | 70-16-0331 |
| R176 | | 330Ω | 70-16-0331 |
| RT1 | | Thermistor, 2.5Ω @ 25°C (part of L1) | 1-011-7008 |
| | | TRANSFORMER | |
| T1 | | Power | 1-017-5400 |
| | or | Power (TTL15/AM, TTL15/C, TTL15/1029, TTL15/875) | 1-017-5391 |
| T2 | | Vertical output | 6-003-0341 |
| T3 | | High voltage (TTL15) | 6-003-0407 |
| | or | High voltage (TTL15/875) | 6-003-0464 |
| | or | High voltage (TTL15/AV) | 6-003-0404 |
| | or | High voltage (TTL15/AM) | 6-003-0496 |
| | or | High voltage (TTL12) | 6-003-0436 |
| | or | High voltage (TTL15/C) | 6-003-0446 |
| | or | High voltage (TTL15/1029) | 6-003-0408 |
| T101 | | Horizontal driver | 1-017-5380 |
| | or | Horizontal driver (TTL15/0, TTL15/AM, TTL15/C, TTL15/1029) | 1-017-5395 |
| | | ZENER DIODE | |
| VR101 | | 1N754A | 78-15-0754 |
| VR102 | | 1N5526 | 1-021-0449 |

| SYMBOL | DESCRIPTION | BBRC PART NUMBER |
|---|---|---|
| | MISCELLANEOUS | |
| V1 | 15 inch CRT | |
| | Assembly, main chassis board (TTL15) | 6-002-0525 |
| | Assembly, main chassis board (TTL15/0) | 6-002-0560 |
| | Assembly, main chassis board (TTL15/C) | 6-002-0582 |
| | Assembly, power supply module (TTL15/1029, TTL15/875) | 6-003-0412 |
| | Assembly, main chassis board (TTL12) | 6-002-0569 |
| | Assembly, main chassis board (TTL12 W/Brt control) | 6-002-0574 |
| | Assembly, main chassis board (TTL15 W/Brt control) | 6-002-0551 |
| | Assembly, switchable power supply module | 6-003-0424 |
| | Assembly, heatsink (TTL15/0) | 6-003-0434 |
| | Assembly, heatsink (TTL15/AM, TTL15/1029, TTL15/C) | 6-003-0446 |
| | Assembly, heatsink | 6-003-0396 |
| | Assembly, heatsink (TTL15/875) | 6-003-0411 |
| | Assembly, heatsink (TTL15/875) | 6-003-0404 |
| | Assembly, main chassis board (TTL15/AV) | 6-002-0620 |
| | Assembly, main chassis board (TTL15/1029) | 6-002-0589 |
| | Assembly, main chassis board (TTL15/875) | 6-002-0537 |
| | Assembly, main chassis board (TTL15/AM) | 6-002-0638 |
| | Assembly, power supply module (TTL15/C, TTL15/AM) | 6-003-0445 |
| | Assembly, power regulator module (TTL15/I) | 6-003-0498 |

TTL15/1029


VIDEO INPUT
VERT SYNC INPUT
HORIZ SYNC INPUT
VHOLD
HEIGHT
V LIN
V DAMP
VID GAIN
BRIGHTNESS
HORIZ CENT
VERT DEFL COIL
FROM T1
FROM CRT SOCKET
FLY TRANSFORMER
HORIZ DEFL COIL
SCHEMATIC
PROD
VER
GENERAL NOTES: UNLESS OTHERWISE SPECIFIED.
1. ALL RESISTORS 1/4 W, 5%. VALUES IN OHMS.
2. ALL CAPACITOR VALUES IN MICROFARADS.
3. [ ] DENOTES PC CARD EDGE CONNECTOR.
4. >< DENOTES MOLEX CONNECTOR.
SELECT AT TEST.
8 MOLEX DETAIL
9. R174 & C136 ARE PART OF PW ASSY.
TABLE


GENERAL NOTES: UNLESS OTHERWISE SPECIFIED.
1. ALL RESISTORS 1/4 W, 5%. VALUES IN OHMS.
2. ALL CAPACITOR VALUES IN MICROFARADS.
3. □ DENOTES PC CARD EDGE CONNECTOR.
4. ⋖ DENOTES MOLEX CONNECTOR.
5. USED WHEN 8V IS APPLIED THROUGH PIN 7
6. SELECT AT TEST.
7. OPTIONAL BRIGHTNESS CONTROL.
8. MOLEX DETAIL 7 C.
9. LAST REF DESIGNATORS USED: R174, C136, CR116, L4, J111, L104, Q115, P 76, T101, VR102, DS101
10. R174 & C136 ARE PART OF PW ASSY.
11. REF NO'S. NOT USED: R173, C134, R162.
12. SEE TABLE
VIDEO INPUT
+55 VDC
VERT SYNC INPUT
HORIZ SYNC INPUT
HEIGHT
V-LIN
V-HOLD
H-HOLD
H-CENT
BRIGHTNESS
H-FREQ
H-GAIN
FOCUS
VERT DEFL COIL
HORIZ DEFL COIL
HV TRANSFORMER
FROM CRT SOCKET
PRODUCTION VERSION
AA
TT_ SERIES
535 875
1-024-0526

# INSTRUCTION MANUAL ADDENDUM

MODEL EFFECTED: TV-15 and TTL Series

SUBJECT: 100-240V Low Voltage Power Supply

This is an optional supply module for use on the TV15 & TTL series data display and is capable of operating from input line voltages of 100V, 120V, 220V or 240V, 50/60Hz.

The power supply input voltage is determined by the setting of the two slide switches located at the rear of the supply. These switches are stamped to indicate the appropriate line voltage setting.

To set the supply for a particular line voltage, the numbers on the two switches are added together. This enables the supply to be set for four different input line voltages. The position of the switches and the resultant input voltages are:

| S2 Position | S3 Position | AC Line Voltage |
|---|---|---|
| 0 | 100 | 100 |
| 20 | 100 | 120 |
| 0 | 220 | 220 |
| 20 | 220 | 240 |

When changing input voltage from 100/120 to 220/240 volt, the fuse (F1) must also be changed.

## FUSE SIZE TABLE

| Input Voltage | Fuse Size |
|---|---|
| 100/120V | 3/4A-125V slo-blo |
| 220/240V | 3/8A-250V slo-blo |

## PART LIST ADDENDUM

| | | |
|---|---|---|
| T1 | Power Transformer | 1-017-5400 |
| S2 | Switch, Slide, SPDT | 1-018-0255 |
| S3 | Switch Slide, 3PDT | 1-018-0256 |
| | Power Supply Module | 6-003-0424 |

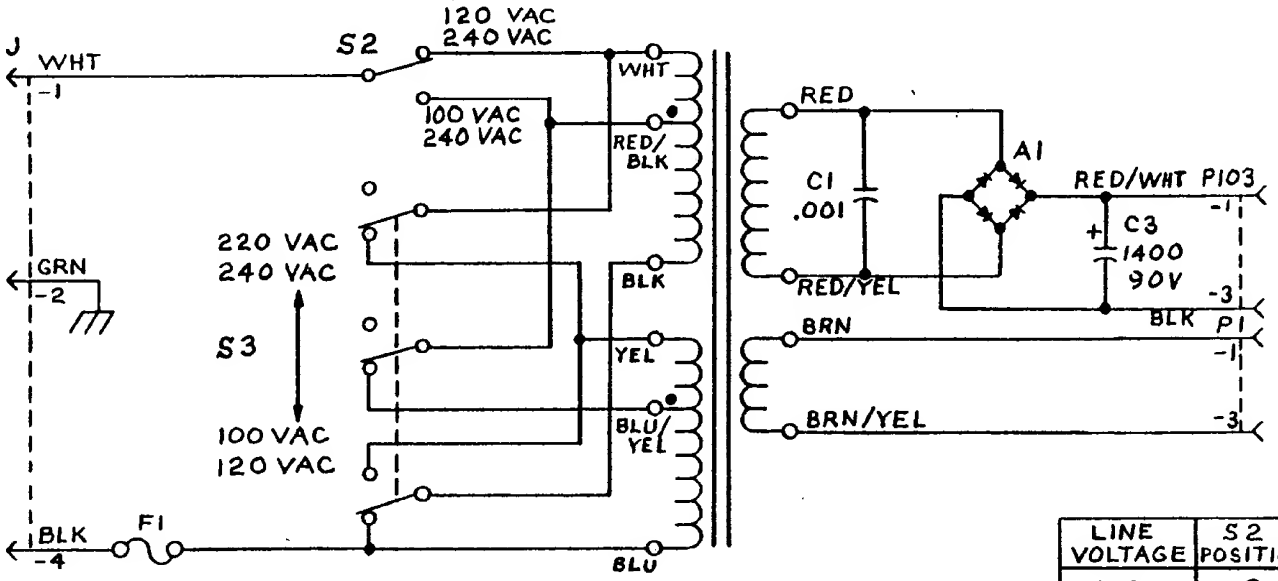



FIG 1: SWITCHING SYSTEM FOR VARIABLE INPUT LINE VOLTAGE SHOWN IN 120 VAC POSITION.

| LINE VOLTAGE | S2 POSITION | S3 POSITION | F1 |
|---|---|---|---|
| 100 | 0 | 100 | 3/4 A 125V SB |
| 120 | 20 | 100 | 3/4 A 125V SB |
| 220 | 0 | 220 | 3/8 A 250V SB |
| 240 | 20 | 220 | 3/8 A 250V SB |

MATERIAL

FINISH

TOLERANCES UNLESS OTHERWISE SPECIFIED

| DECIMALS | TOL ± | FRACTIONS | TOL ± |
|---|---|---|---|
| .XX | .030 | 0 TO 8 | 1/32 |
| .XXX | .020 | 8 TO 24 | 1/16 |
| .XXXX | .010 | ABOVE 24 | 1/8 |

DIMENSIONS ARE IN INCHES

THREADS-CLASS # 2 FIT AFTER PLATING

ANGULAR TOL. ± 2°

DO NOT SCALE DRAWING

BALL BROTHERS RESEARCH CORP. MIRATEL DIVISION 1501 TERRACE DRIVE SAINT PAUL, MINNESOTA

| | SIGNATURE | DATE |
|---|---|---|
| DRAFTSMAN | R D Thomas | 4-11-75 |
| CHECKER | T O Kelley | 4-16-75 |
| DESIGNER | | |
| ENGINEER | | 4-17-75 |

TITLE: SWITCHABLE POWER SUPPLY TV-15 & TTL SERIES

SIZE: B | DRAWING NO.: 1-024-0547 | REV.: A

USED ON: TTL SERIES, TV-15 | SCALE: NONE | SHEET: 1 OF 1